

# *Assessing the impact of anticyclonic flow and convection on stratospheric composition over North America during the summertime*

Jasna Pittman, Steven Wofsy, Bruce Daube

Jessica Smith, Maryann Sargent, James Anderson



Ru-Shan Gao, Ed Dlugokencky



Elliot Atlas, Maria Navarro



Sue Schauffler



Paul Bui, Lenny Pfister



Qing Liang

Tao Wang

## Motivation

Determine the changes in stratospheric composition and circulation (e.g., the Brewer-Dobson circulation) as a result of increasing greenhouse gases.

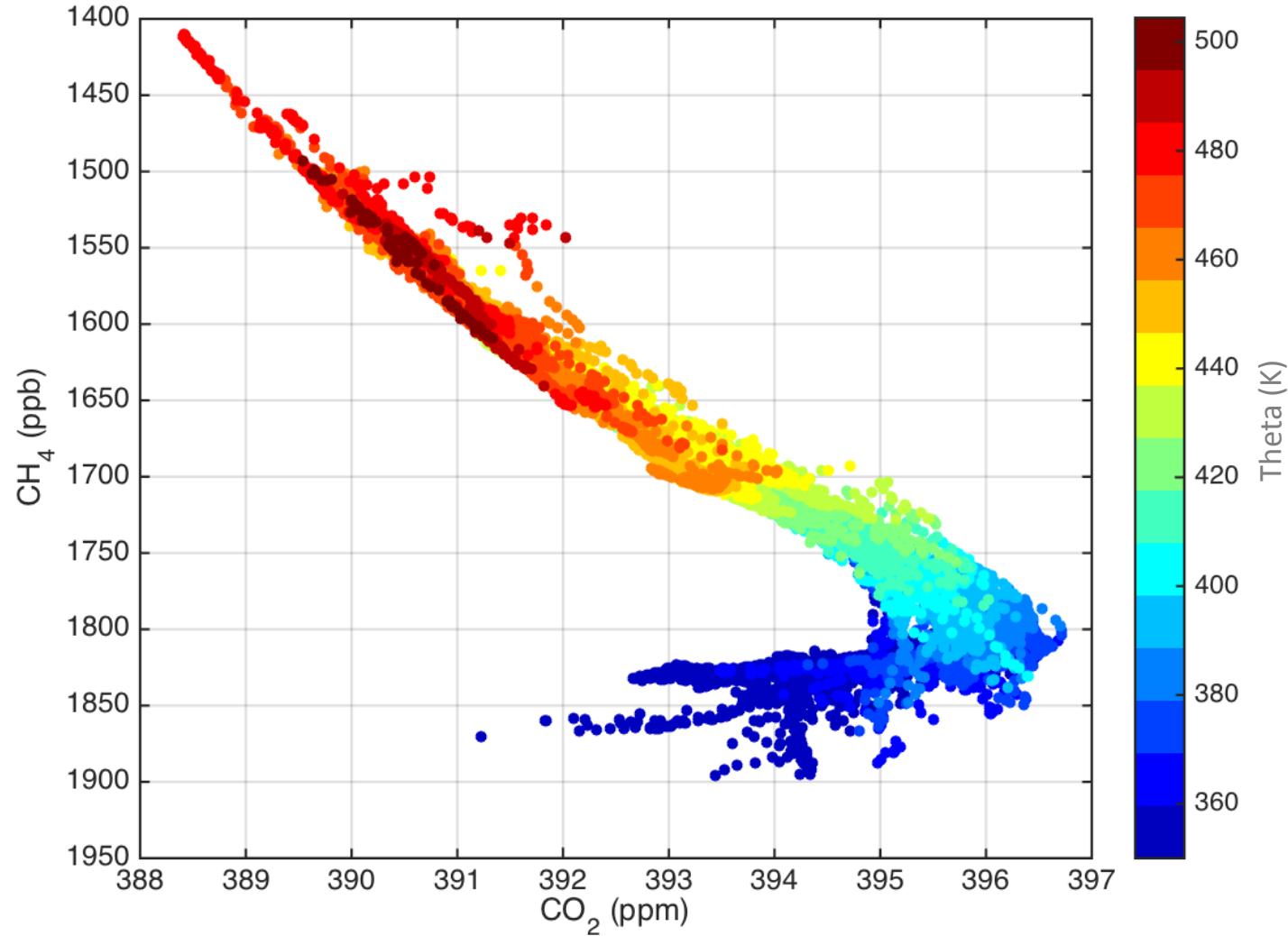
## Scientific questions:

- What controls the variability and distribution of chemical tracers in the UT/LS over North America?
- How well do models capture the variability in chemical composition and age of air in this region?

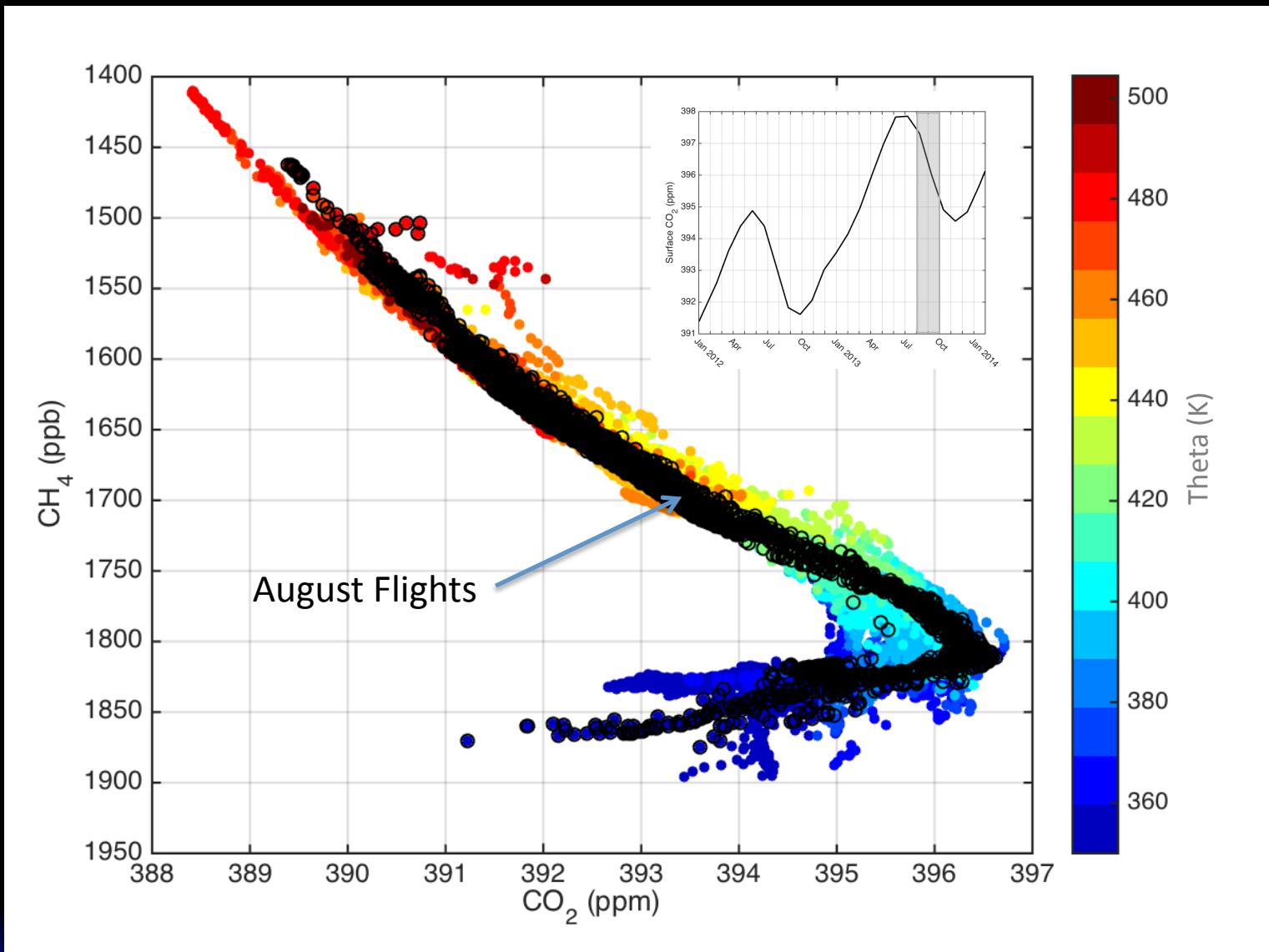
\* GEOS-5 model

\* TA&M Lagrangian trajectories

# $\text{CO}_2$ vs $\text{CH}_4$

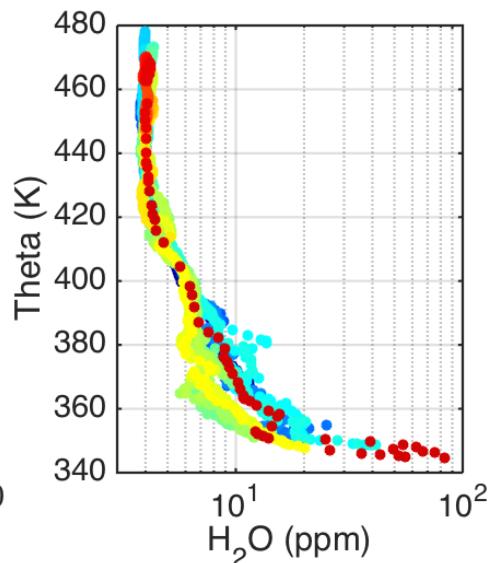
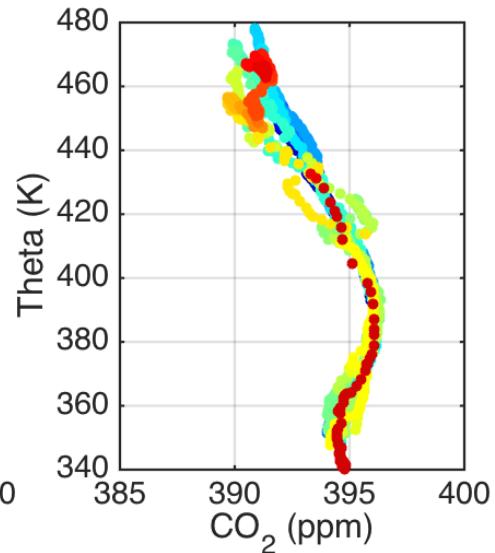
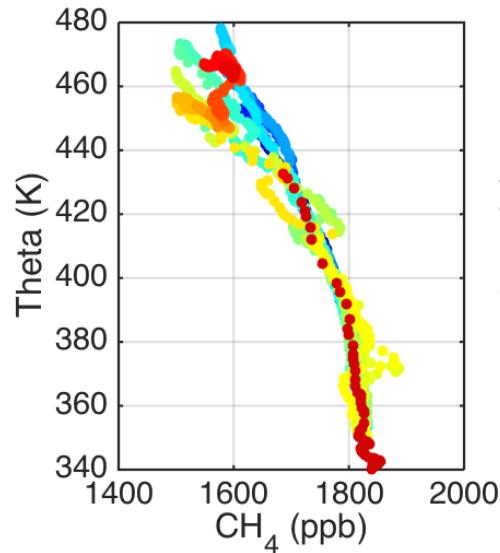
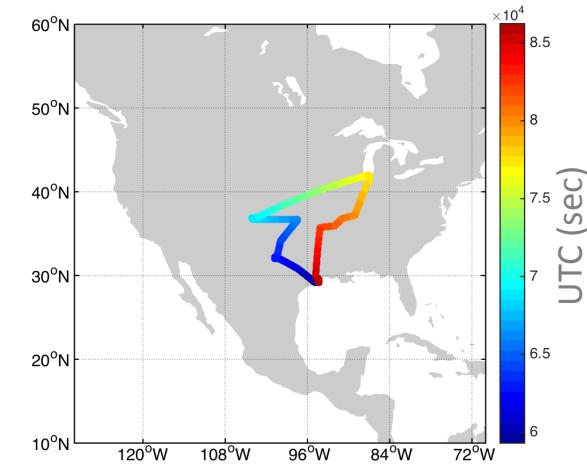
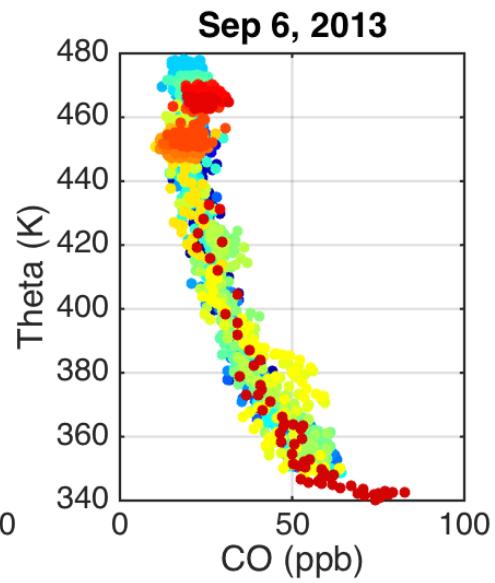
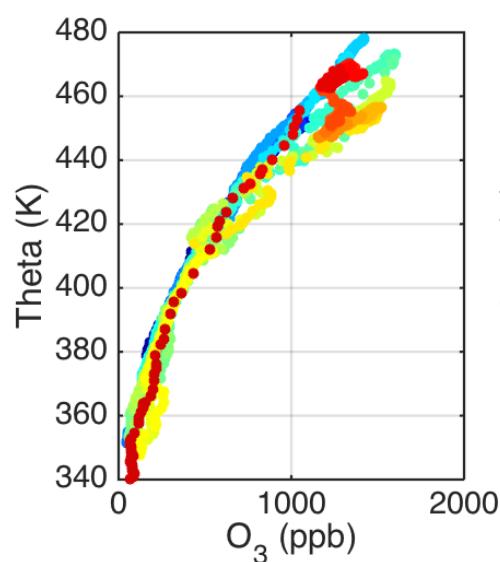


# $\text{CO}_2$ vs $\text{CH}_4$ : Time Variability

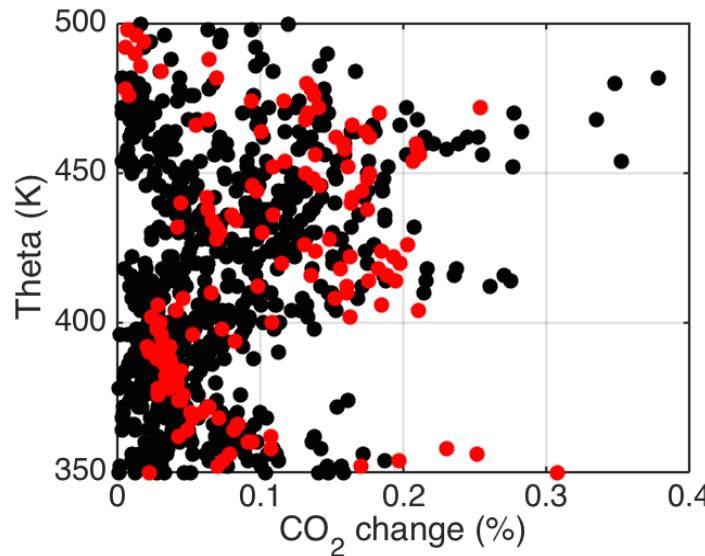
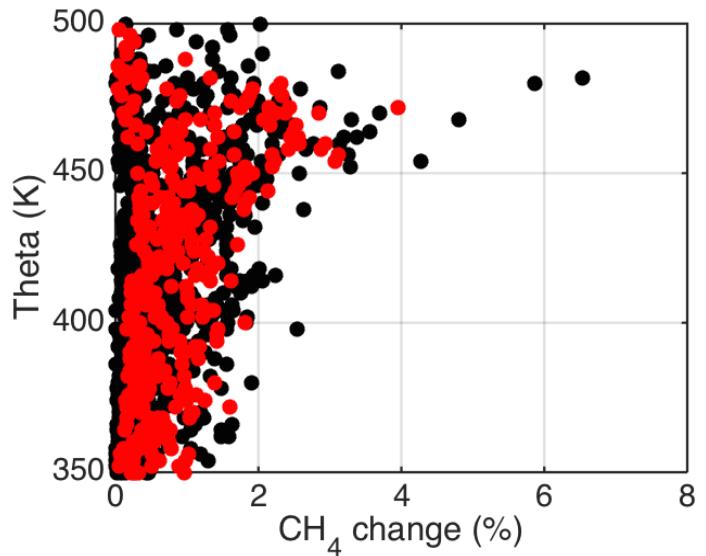
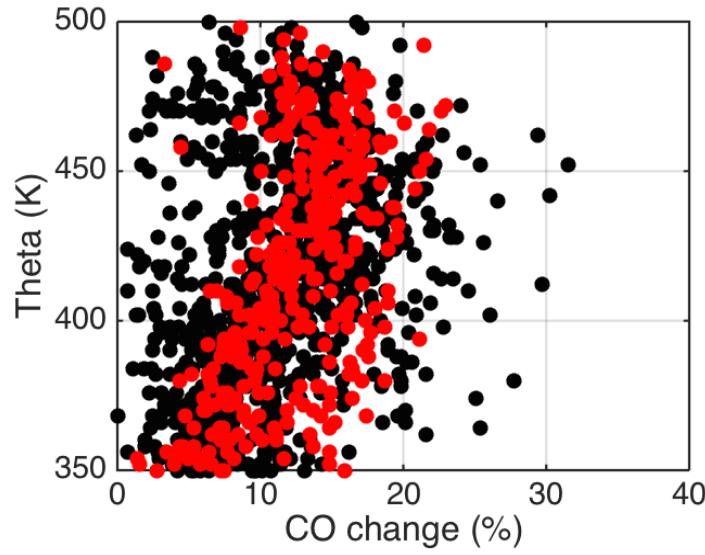
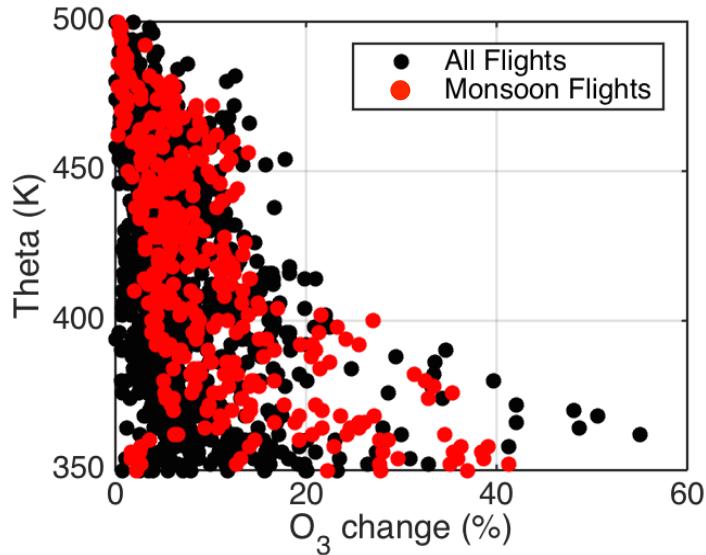


# Large-Scale Circulation during SEAC<sup>4</sup>RS

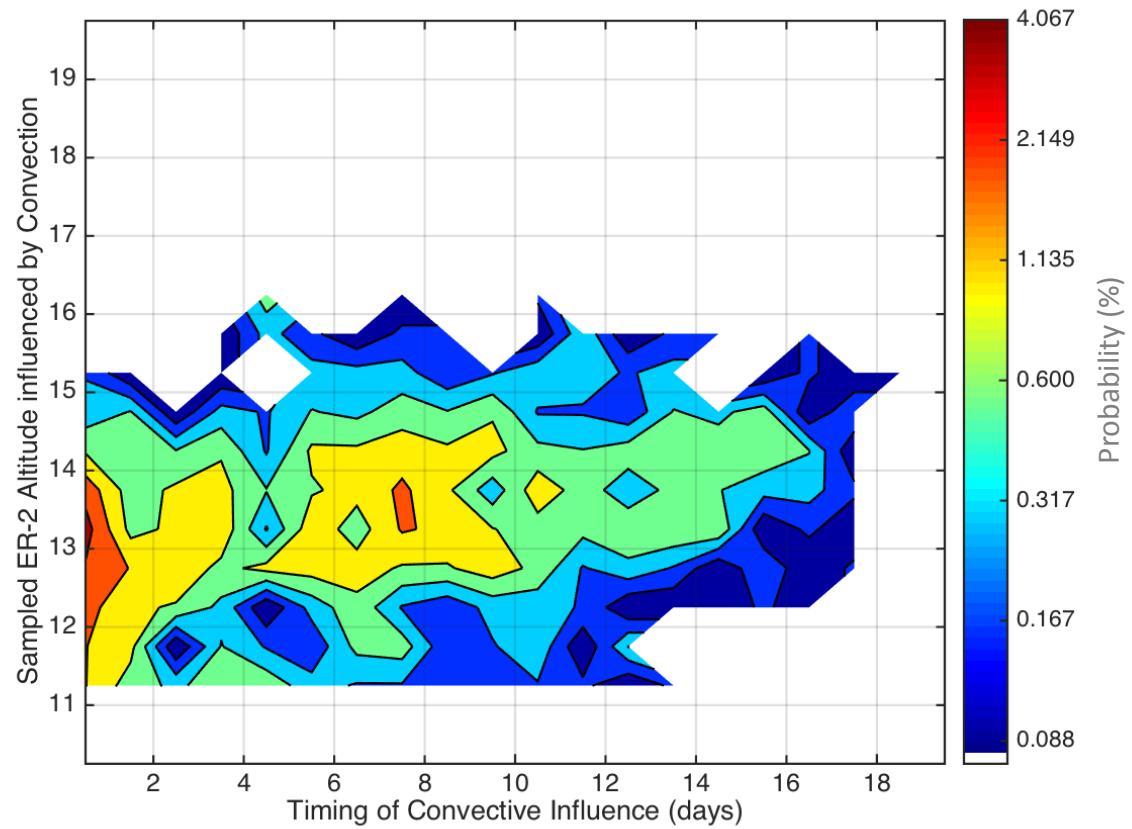
Flights targeting upper level anticyclone: Aug 8, 14, 16, 27, Sep 6



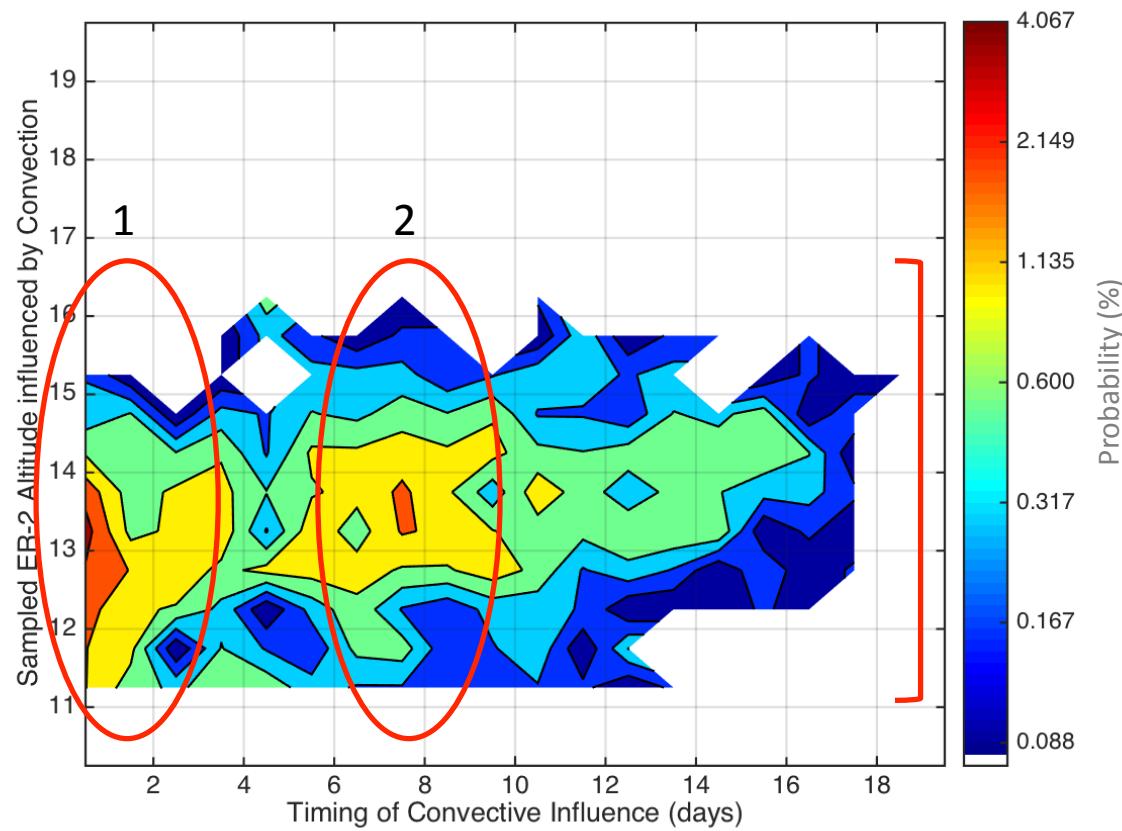
# Tracer Variability in Monsoon vs non-Monsoon Flights



# Convective Influence: Altitude vs Time



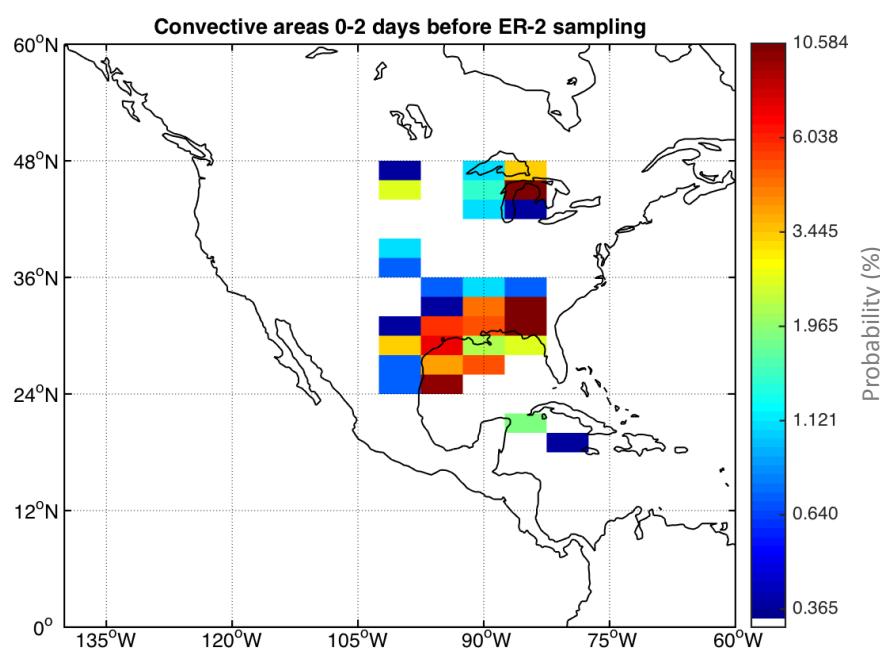
# Convective Influence: Altitude vs Time



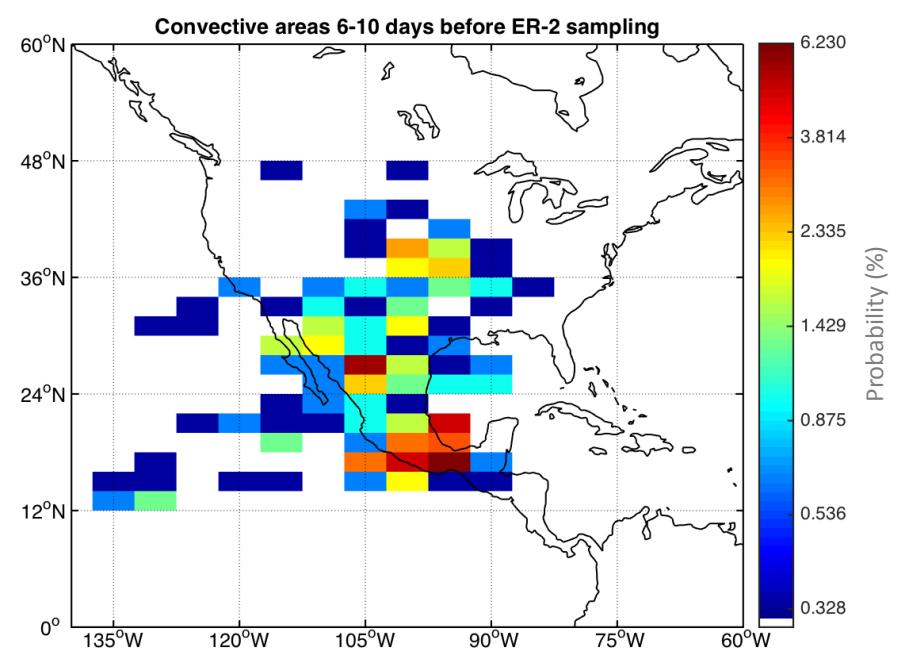
Mode 1: 0 – 2 days

Mode 2: 6 – 10 days

# Convective Influence: Geographical Locations

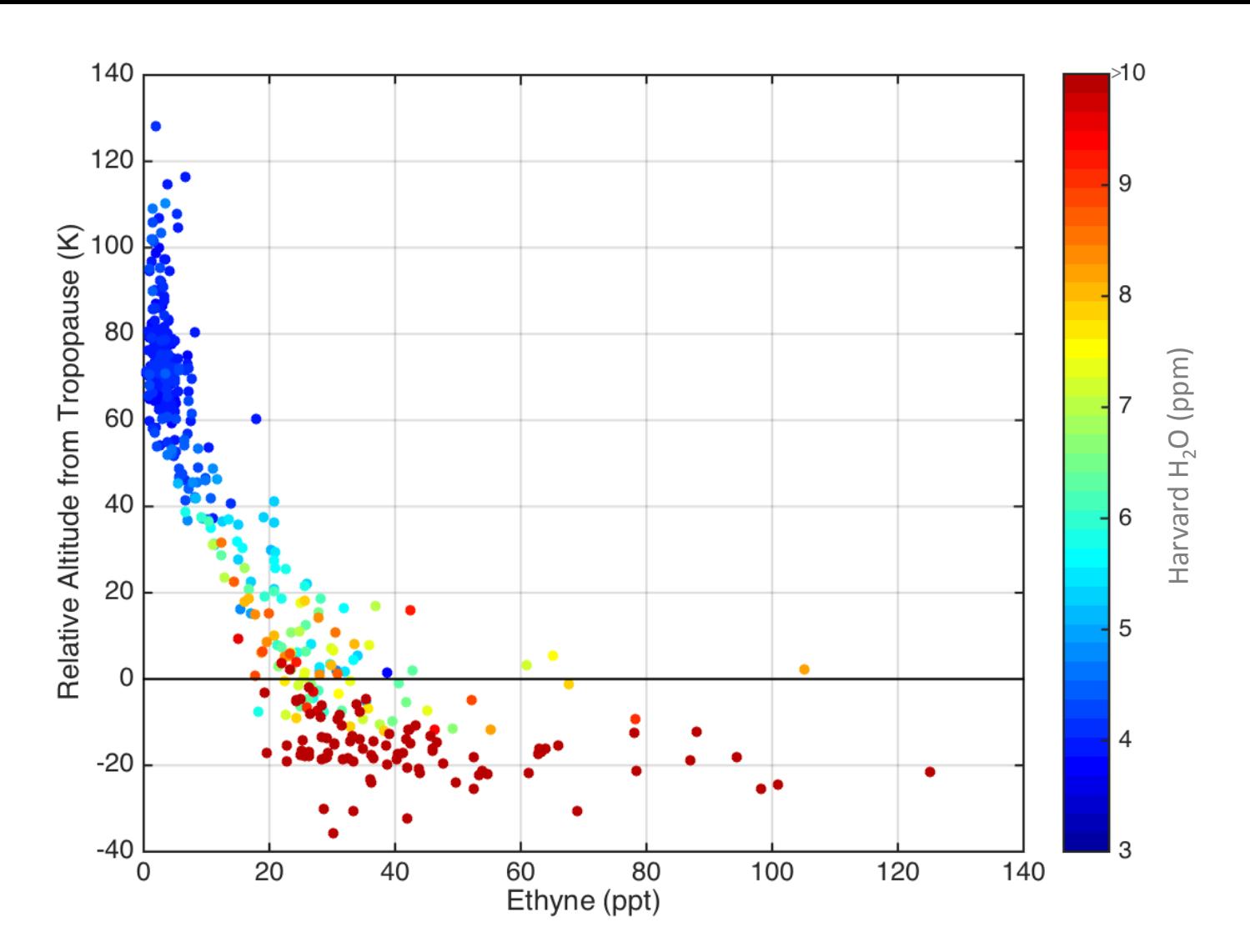


Mode 1: 0 - 2 days



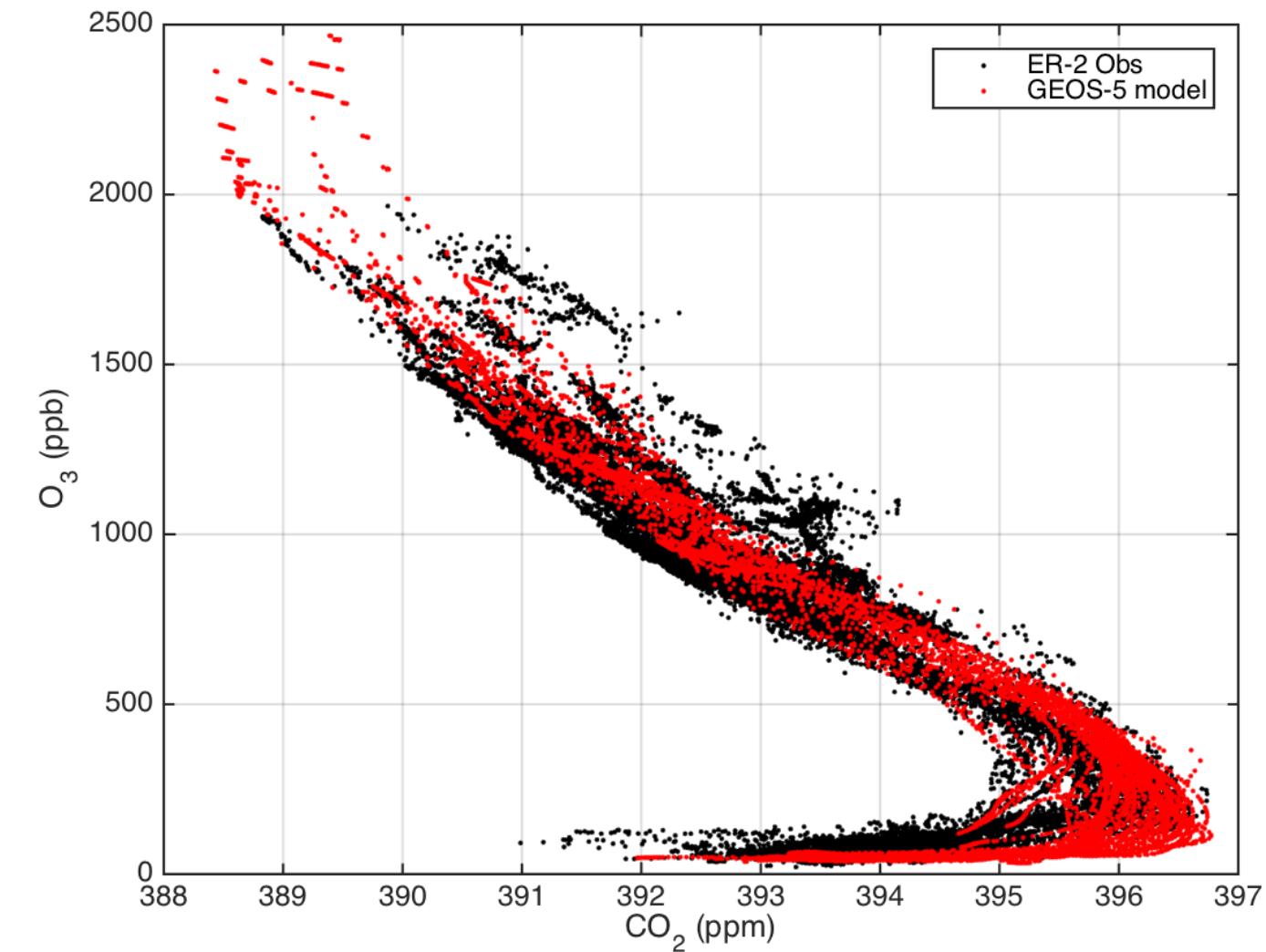
Mode 2: 6 – 10 days

# Convective Injection?



Lifetime  $\sim$  3 weeks

## CO<sub>2</sub> vs O<sub>3</sub>: Observations vs GEOS-5

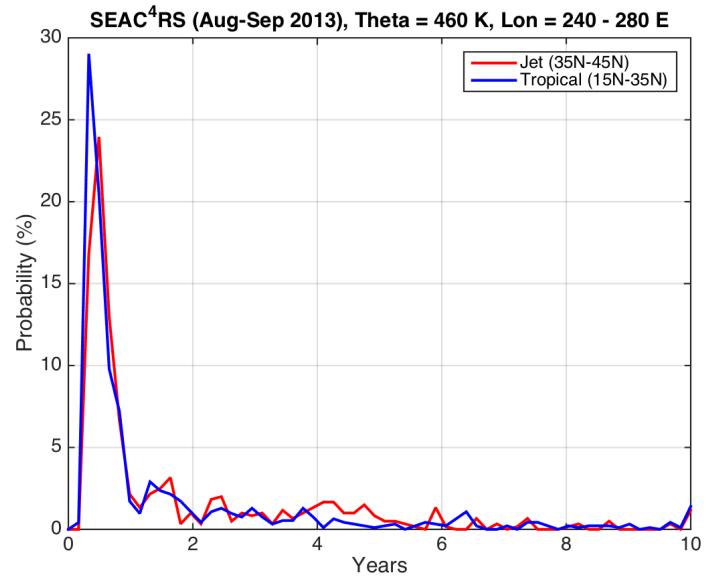


Model can provide spatial and temporal context for SEAC<sup>4</sup>RS measurements

# Midlatitude Age Spectrum

## Trajectory Analysis

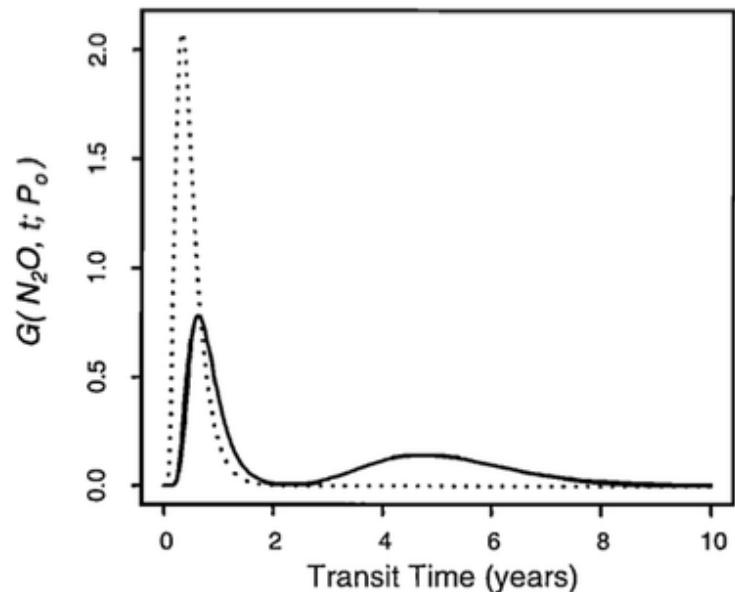
- Daily forward trajectories starting at 355 K, 20 S to 20 N, all longitudes, 2000 to 2014
- Circulation: ERA interim
- Temperatures: MERRA (2000-2007)  
GPS (2007-2014)



Reference: Wang *et al*, ACP, 2015

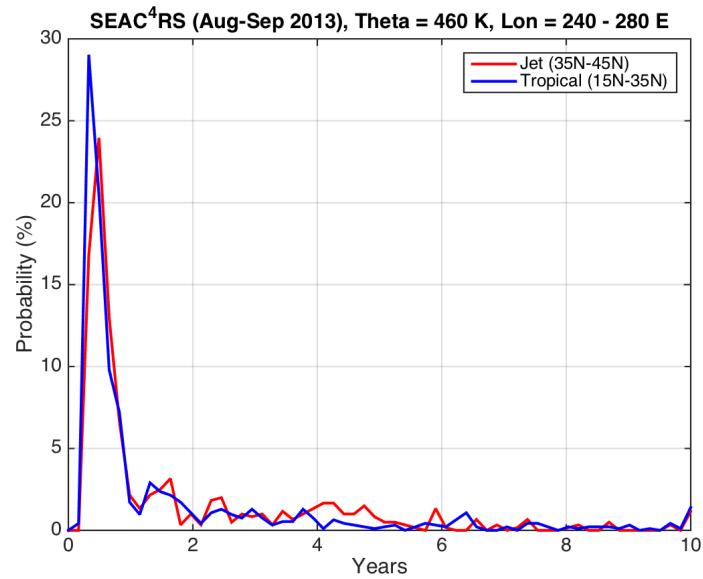
Modal Age (yrs)	Mean Age (yrs)
0.49	1.72
0.33	1.53

# Midlatitude Age Spectrum



**Figure 11.** Annual mean tropical age spectrum for 460 K (dotted line) and the midlatitude age spectrum for 245 ppbv N<sub>2</sub>O (~460 K, solid line).

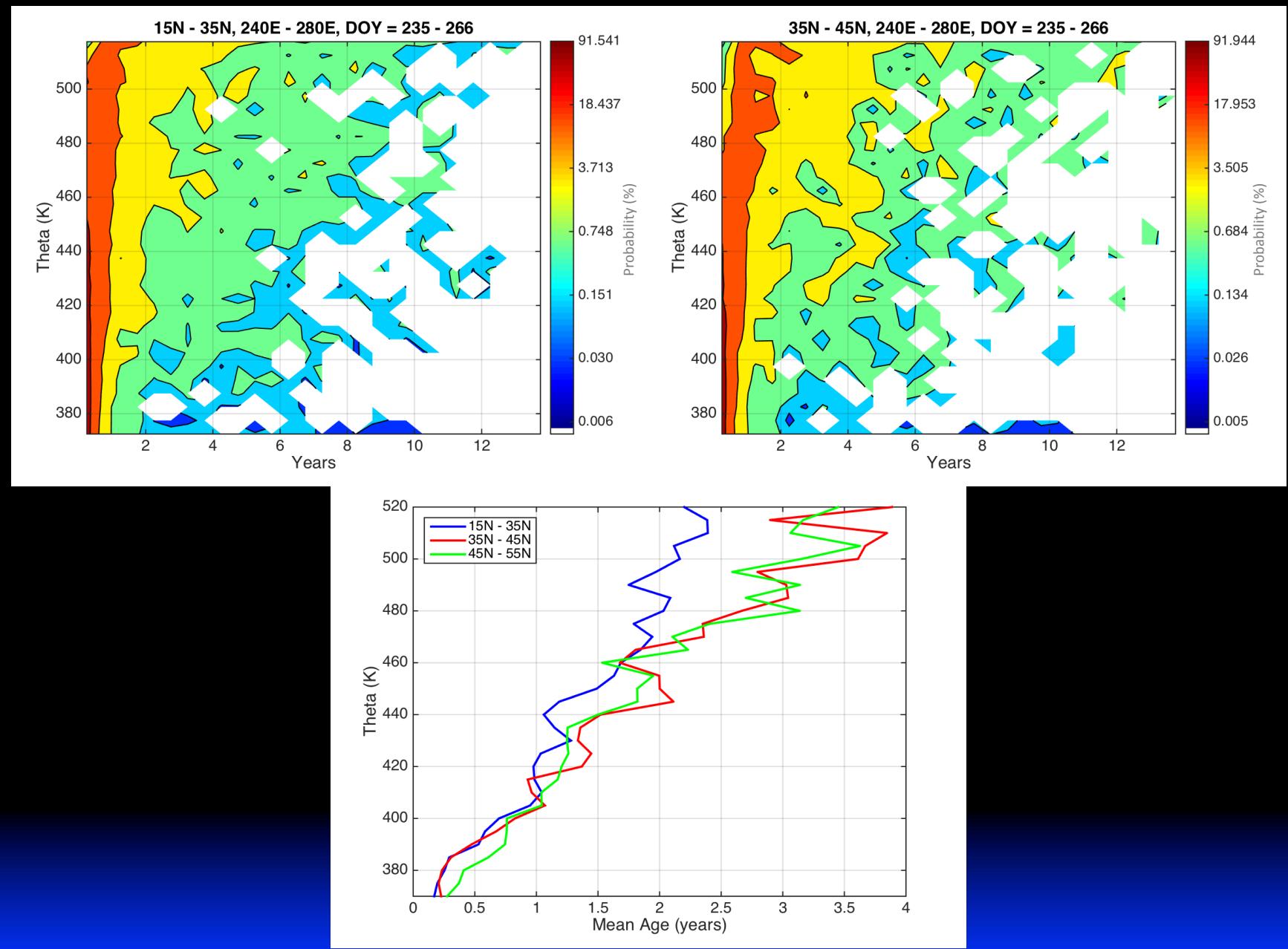
*Andrews et al, JGR, 2001*



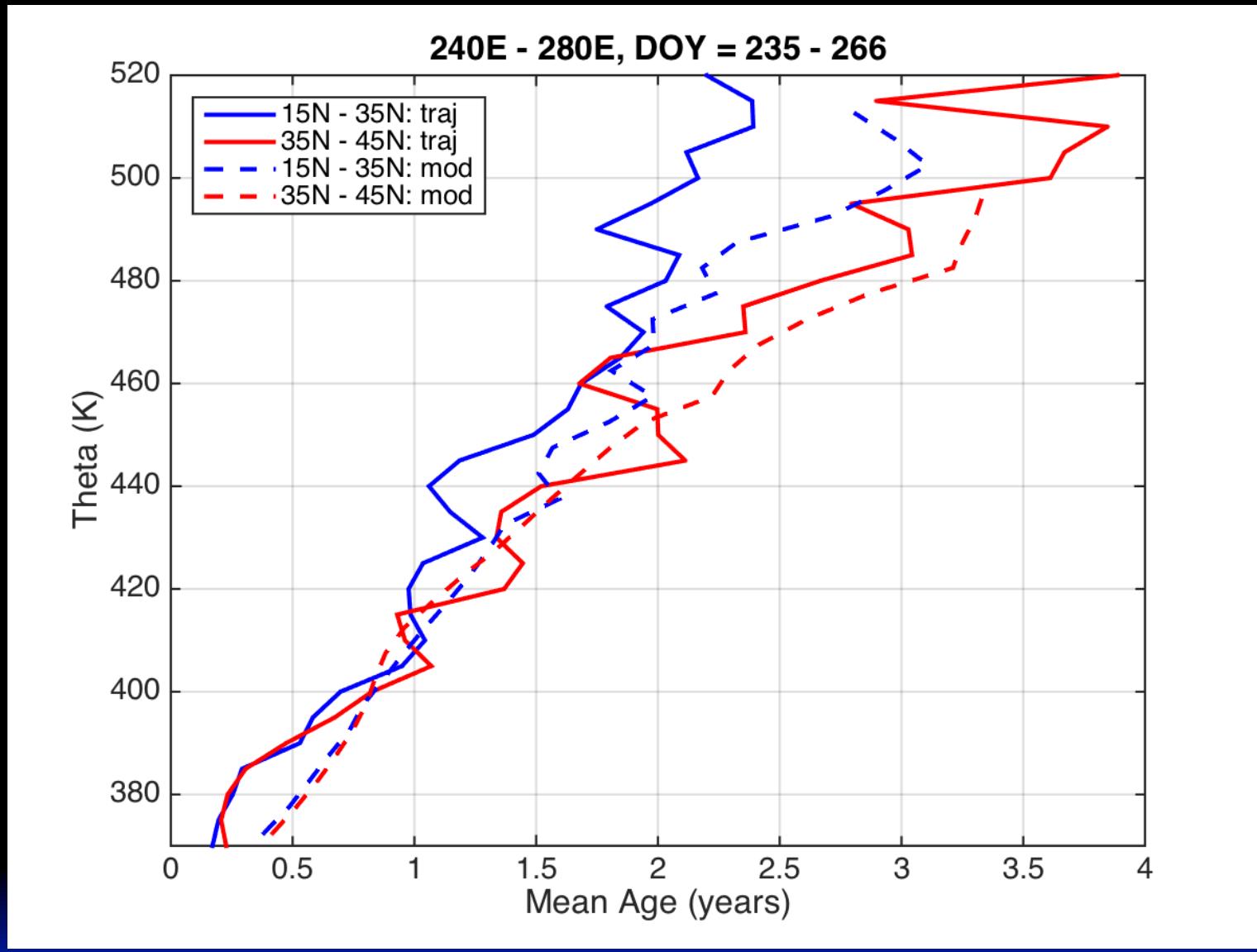
Modal Age (yrs)	Mean Age (yrs)
0.6	2.8

Modal Age (yrs)	Mean Age (yrs)
0.49	1.72
0.33	1.53

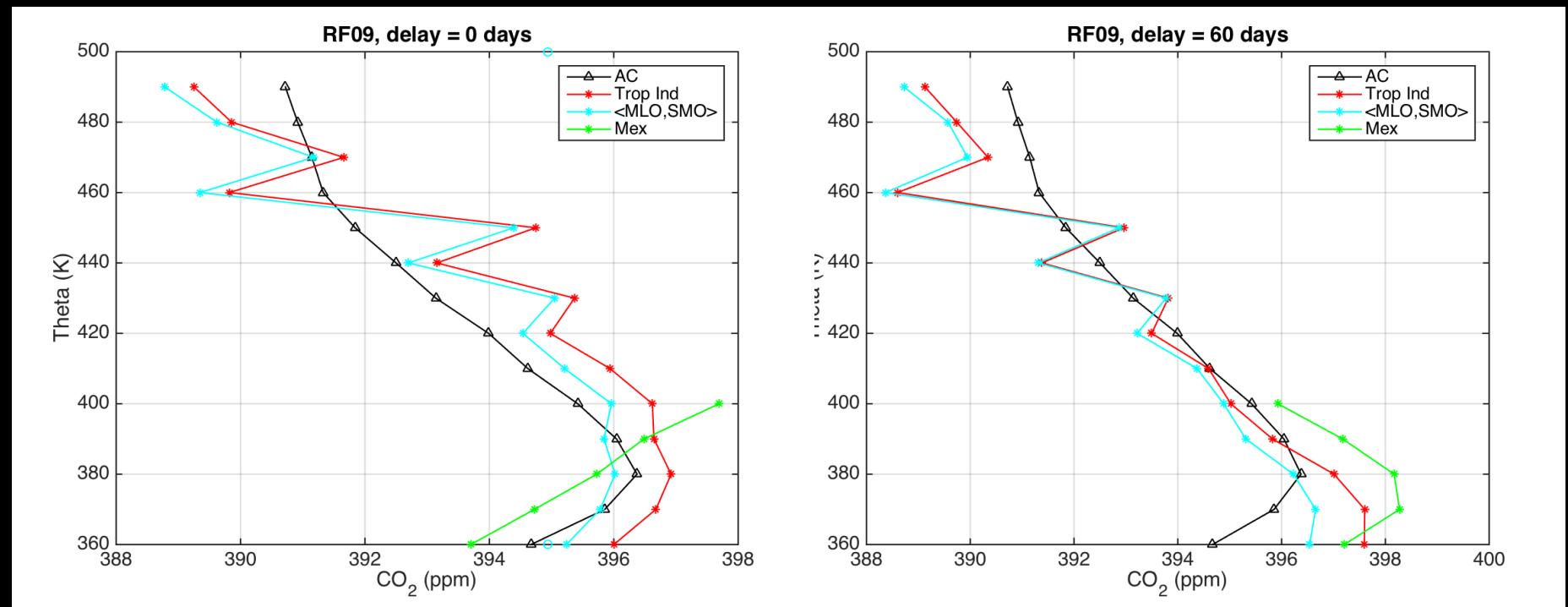
# Midlatitude Age Spectrum and Mean Age as a Function of Height



# Mean Age: GEOS-5 vs Trajectories



# Reconstructing CO<sub>2</sub> Vertical Profiles from Age Spectrum



- Lag times between SEAC<sup>4</sup>RS and surface measurements
- Tropical stations for the lower stratosphere
- Monsoon stations (Mexico) for the upper troposphere

# Summary

- Variability observed in tracer fields in the lower stratosphere was not distinctively affected by upper level large-scale anticyclone or by convection.
- GEOS-5 model does very well in reproducing the observed tracer-tracer correlations.
- Ensemble of daily initiated forward trajectories can be used to derive age spectrum in the lower stratosphere and reproduce the observed CO<sub>2</sub> concentrations.

An aerial photograph showing a vast expanse of white, puffy cumulus clouds against a clear blue sky. The clouds are arranged in long, parallel, wavy bands that stretch across the frame, creating a sense of depth and movement.

**THANK YOU!**